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A NOVEL APPROACH FOR IRIS RECOGNITION SYSTEM BASED ON DCT FEATURES

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ABSTRACT

This paper proposes a new method for biometric identification and verification. The biomedical literature suggests that irises are as distinct as fingerprints or patterns of retinal blood vessels. Current iris recognition systems are unable to deal with noisy data and substantially increase their error rates, especially the false rejections, in these conditions. We propose an iris classification method that divides the segmented and normalized iris image into different regions, makes an independent feature extraction and comparison for each region. We have to reduce the error rate and also increase the recognition rates. Hence UBIRIS database consisting of the original images are used. Artificial images are used in the database (CASIA) which is used in the existing system for Iris recognition purpose.

KEYWORDS: DCT Matrix, Iris Recognition, Hamming Distance

INTRODUCTION

For identification we maximum used body characteristics such as face, voice, height, blood, finger print and gait for thousands of years for identification each other. The idea of using a number of body measurements to identify criminals in the mid-19th century is most significant and practical discovery of the distinctiveness of the human fingerprints in the late 19th century[1]. After this discovery, many law and defences enforcement departments embraced the idea of first “booking” the fingerprints of criminals and storing it ina database. Later, the leftover fingerprints in case of crime and identification of criminal in large amount of database is matched with fingerprints in the database to determine the identity of the criminals.

Iris recognition system is a process in which the iris pattern of an individual’s eyes is first scanned [2], and then enrolled in the iris recognition system database. Technology of iris recognition system is advanced than that of retina scanning. Since the iris pattern of eyes is practically impossible to forge or otherwise duplicate, the identification based on iris recognition system is almost fool-proof and accurate. In many organizations, security administrators use iris recognition system to identify the individuals before they are allowed to access classified information. The process of iris recognition system is now replacing older biometric identification systems.

Iris recognition system with Iris scanner/camera for Biometrics enrolment& verification BioEnable[3] offer Single & Dual eye Iris recognition system for government and commercial applications. Our Iris scanner provides high quality iris image capture as per international standard for wide range of applications. The Dual Iris Scanner ensures clear in-focus iris images with the sharpest iris texture, unlike most auto focusing iris cameras; accomplished via use of patented algorithm. Iris authentication is one of the popular and best ways of biometric authentication when used in highly sensitive zones. Iris authentication technology is now widely accepted in many industries for authenticating legitimate users. In

order to authenticate using iris authentication, users must be registered in iris scanner devices. While registering a user, iris scanner captures the image of iris patterns and stores it in the database.

Whenever a registered user attempts to access a protected device, iris scanner compares iris patterns against the one stored in the database[4].

Once recognized successfully, it authenticates the user. Although the technology is very accurate and reliable, deploying iris authentication can sometimes be a very tedious task. Moreover, Iris authentication technology is very costly and there it mostly used in enterprise-level industries [5].

The proposed iris recognition system consists of an automatic segmentation system which is based on the Hough transform. The extracted iris region was then normalised into a rectangular block with constant dimensions to account for imaging inconsistencies. Finally, the input image pixels is divided into a 4 by 4 block and afterwards the two dimensional DCT matrix coefficient is computed for each block to obtained the iris template. The Hamming distance was employed for classification of iris templates, and two templates were found to match if a test of statistical independence was failed. The system performed with perfect recognition on a set of 75 eye images with 0% false accept and false rejects; however, tests on another set of a 185 images resulted in false accept and false reject rates of 0.19% and 0.26% respectively. This shows that the proposed algorithm is a reliable and accurate biometric technology which is having less false acceptance as well false rejection rate as compared to other existing work.

BIOMETRICS

Biometrics refers to ‘measurement of life’. It is the methodology of measurement [6] and analyses of the biological or physiological data of the living body for identification of an individual for authentication purpose. It makes use of the unique traits of human for the identification [7]. Identification means one to many, whereas verification is one to one. Firstly, a sensing device such as a camera captures the raw biometric data. Then this captured raw biometric sample is processed and the unique biometric sample is extracted from it which is sometimes called match sample or biometric sample or template. Biometric systems are broadly divided into two categories as shown [8] in table below:

Table 1: Types of Biometric Systems

Physiological biometrics	Behavioral biometrics
Finger print	Signature
Iris	Speech
Hand print	Keystroke
DNA	
Facial pattern	

Advantages of Using Biometrics

- Easier fraud detection.
- Better than password/PIN or smart cards.
- No need to memorize passwords.
- Require physical presence of the person.

- Physical characteristics are unique.
- It provides accurate results

Table 2: Comparision of Biometric Techniques

Biometrics	Universal	Unique	Performance
Face	High	Low	Medium
Fingerprint	Medium	High	High
Iris	High	High	High
Signature	Low	Low	Low
Voice	Medium	Low	Low

HUMAN IRIS

The eye is a slightly asymmetrical globe, about an inch in diameter. [9]The front part of the eye (the part you see in the mirror) includes:

- The iris (the pigmented part).
- The cornea (a clear dome over the iris).
- •The pupil (the black circular opening in the iris that lets light in).• The sclera (the white part).
- The conjunctiva (a thin layer of tissue covering the front of the eye, except the cornea)[10].

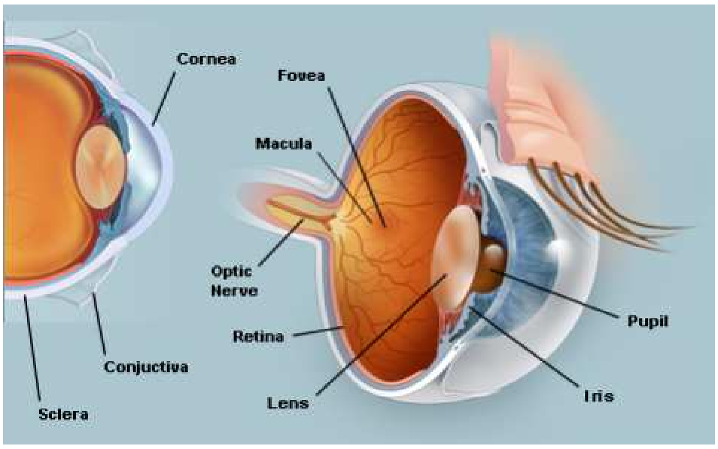

Figure 1: Human Iris

Just behind the iris and pupil lies the lens, which helps to focus light on the back of the eye. Most of the eye is filled with a clear gel called the vitreous[11]. Light projects through the pupil and the lens to the back of the eye. The inside lining of the eye is covered by special light-sensing cells that are collectively called the retina. The retina converts light into electrical impulses. Behind the eye, the optic nerve carries these impulses to the brain. The macula is a small extra-sensitive area within the retina that gives central vision. It is located in the centre of the retina and contains the fovea, a small depression or pit at the centre of the macula that gives the clearest vision.

Methodology of Iris Recognition

In 1993, Daugman[3] presented one of the most relevant methodologies, constituting the basis for many functioning systems. In the segmentation stage, this author introduced differential operator to find both the iris inner and

outer borders. By Daugman's [12] methodology the visible texture of a person's in real-time video image is encoded into compact sequence of multi-scale quadrature 2-D Gabor Wavelet coefficients, whose most-significant bits comprise a 256-byte which became the basis of all publicly deployed iris recognition systems. Daugman iris recognition system is based on four key points. Image pre-processing and normalization is significant part of iris recognition systems. The stages involved in Iris reorganization are[13],

- Image acquisition.
- Segmentation.
- Normalization.
- Feature extraction.
- Matching.

Most iris recognition systems consist of five basic modules leading to a decision:

- The *acquisition* module obtains an image of the eye.
- The *segmentation* module localizes the iris's spatial extent in the eye image by isolating it from other structures in its vicinity, such as the sclera, pupil, eyelids, and eyelashes.
- The *normalization* module invokes a geometric normalization scheme to transform the segmented iris image from Cartesian coordinates to polar coordinates.
- The *encoding* module uses a feature-extraction routine to produce a binary code.
- The *matching* [14]module determines how closely
- The produced code matches the encoded features stored in the database.

Segmentation

Circular Hough transform based approach is used here for detecting the upper and the lower eyelids of the eye, and the iris and pupil boundaries [15]. This procedure involves generation of an edge map, which is done through employing *canny edge detection [16]* technique. In this, gradients are biased in the vertical direction for the outer iris (sclera boundary), as recommended by Wildes et al. system. On the other hand, gradients were weighted equally both in horizontal and vertical directions for the inner iris (pupil boundary). The procedure involves,

Edge Map

The edge map is generated through the use of Canny edge detector technique, it involves the following basic steps:

- **Step1:** Read the input eye image.
- **Step 2:** Use of a Gaussian filter, giver by the equation given below,

$$G(x,y) = \frac{1}{2\pi\sigma^2} e - \frac{x^2 + y^2}{2\sigma^2}$$

where σ is the standard deviation. The value σ is 2 for both the data base.

- **Step 3:** Then on the smoothed image, first derivative operator is applied.

  Two outputs are stored

- Gradient=$\sqrt{x^2 + y^2}$.
- Arctan = (-X/Y).

  Here X is the horizontal gradient and Y is the vertical gradient.

- Step 4: Non-maxima suppression is employed to set the values on the pixels that are not actually on the ridge top as zero, so that only the dominating edges are generated.
- Step 5: Then two threshold T1 and T2 (T1>=T2) are considered in order to control the output of the final edge map. All the pixels with a value higher than T1 are marked as edge points. All the pixels adjacent (using eight connectivity) to edge points and with a value higher than T2 are marked as edge points.

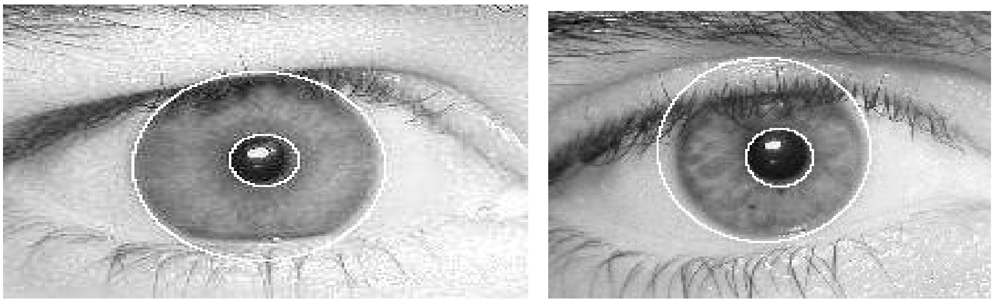

Figure 2: Segmented Two Images are of UBIRIS Database

Normalization and Enhancement

Daugman's rubber sheet model technique [17] was employed to demonstrate the *normalization* of the iris regions. The reference point here refers to the centre of the pupil, and the radial vectors that are considered pass through the iris region. Along each radial line, a stable number of data points are selected which are referred to as the *radial resolution* and the *angular resolution* is defined as the total number of the radial lines [18] that are available around the region of the iris. Since the pupil can sometimes be non-concentric to the region of the iris, therefore a remapping formula is employed [19] to rescale the points depending upon the angle around the circle. This is given by:

$$r' = \sqrt{\alpha\beta} \pm \sqrt{\alpha\beta^2 - \alpha - r_1^2}$$

With $\alpha - o^2_x + o^2_y$

$\beta - \cos(n - \arctan(o_y / o_x) - \Theta)$

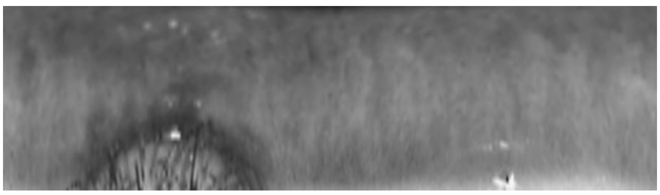

Figure 3: Normalized Eye Image

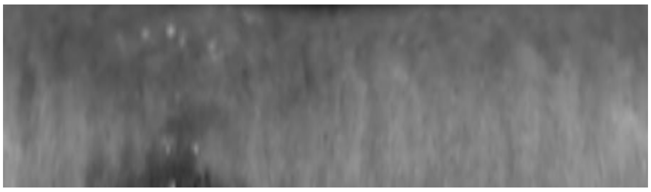

Figure 4: Region of Interest Extracted

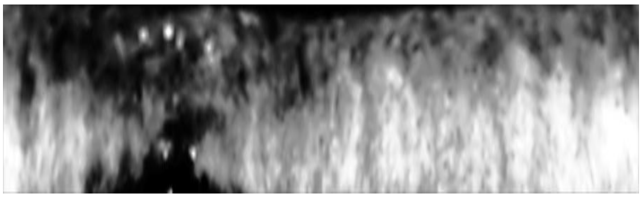

Figure 5: Final Enhance Image for Feature Extraction

Feature Extraction

For feature extraction of the normalized iris image, *Discrete Cosine Transform* (DCT) matrix [20] is used. The DCT matrix is given by -

$$T_{ij} = \begin{cases} \dfrac{1}{\sqrt{n}} \text{ if } i = 0 \\ \sqrt{\dfrac{2}{n}} \cos\left[\dfrac{(2j+1)i\pi}{2n}\right] \text{ if } i > 0 \end{cases}$$

For a 4x4 block, the following results are observed and these are shown in the matrix below:

$$T = \begin{bmatrix} 0.5000 & 0.5000 & 0.5000 & 0.5000 \\ 0.6533 & 0.2706 & -0.2706 & -0.6533 \\ 0.5000 & -0.5000 & -0.5000 & 0.5000 \\ 0.2706 & -0.6533 & 0.6533 & -0.2706 \end{bmatrix}$$

Where the first row i=1 has all entries equal to $1/\sqrt{4}$(as defined in the equation above), the column of T form an orthonormal set so T here, represents an orthonormal matrix. The DCT matrix is more efficient and faster as compared to two dimensional DCT which is used for square input images. DCT is used in many images compressing technique [20].

In this case, the input images are divided into a set of 4-by-4 blocks and thereafter the two dimensional DCT is employed to each block for obtaining the DCT coefficients. The obtained DCT coefficients are then binarized to form the templates of the image. Now to reduce the size of template, the most discriminating coefficients of DCT matrix are extracted and binarized. For binarization, the value of positive coefficient is assumed as one and the value of negative coefficient is discarded.

Matching

For the comparison of the two iris codes, the hamming distance algorithm is employed. Since the iris region contains features with very high degrees of freedom, and each iris produces a bit-pattern which is independent to that

produced by another iris, whereas the codes produced by the same iris would be similar. If two bits patterns are completely independent, then the ideal Hamming distance between the two patterns will be equal to 0.5. It happens because independent bit pattern are completely random. Therefore, half of the bits will agree and half will disagree between the two patterns. The [21] Hamming distance is the matching metric employed by Daugman, and calculation of the Hamming distance is taken only in bits that are generated from the actual iris region.

The Hamming distance will be defined as follows:

$$HD = \frac{1}{N}\sum_{j=1}^{N} X_j \oplus Y_j$$

Where X_j and Y_j are the two bit wise template to compare and N is the number of bits represented by each templates. The Hamming distance can be computed using the elementary logical operator XOR (Exclusive-OR) and thus can be completed very quickly. In the present case, the HD is 0.445 which signifies that if the hamming distance between the two templates is below 0.445 than both the irises are of same eye and if the HD[22] value falls above 0.445, it signifies that both the irises are from different eye.

RESULTS AND DISCUSSIONS

To evaluate the performance of the proposed method, the iris images are collected from the largest available CASIA database version4.1. Almost 990 images of 198 different persons are taken. The entire testing is done on the *Matlab* 7.5 platform and the laptop of 1.85GHz processor and 1GB RAM is used to run our prototype model. The following results are obtained. As it is clear from figure, that the inner class and inter class hamming distances are lying separately and there is no overlapping between both the hamming distances.

Table 3: FAR and FRR

	HD	**FAR**	**FRR**
Proposed Method	0.445	0.35%	0.00%

False Acceptance Rate (FAR) and the False Rejection Rate (FRR) which is defined as the acceptance of a false person and rejection of a genuine person for a given value of hamming distance respectively. The performance evolution of any iris recognition system is done on the basis of Recognition Rate (RR) and Equal Error Rate(EER), defined as the number of the correct recognition and the point where the FAR and FRR both are equal in value respectively. In this case, the value of RR is 99.79% and EER is 0.16%. The table 3 shows the comparison of existing and well-known iris recognition and table 4 shows the speed comparison between existing systems. Both the tables show that the algorithm which has been proposed here has a higher recognition rate as well as higher speed. Although, Daugman system has high recognition rate than the proposed system, but the Daugman system comparatively has low speed. On the other hand the Boles system offers high speed but it has low recognition rate and higher EER. Therefore when both speed and recognition rate are taking into consideration, the proposed algorithm is far better than the existing ones.

Table 4: Comparison between RRs and EERs

Methods	Recognition Rates	Equal Error Rates
Daugman(5)	100%	0.08%
Boles(8)	92.64%	8.13%
Tan(12)	99.19%	0.57%
L.Ma(19)	99.60%	0.29%
Proposed	99.82%	0%

Table 5: Speed Comparison between Existing Methods

Methods	Feature Extraction(ms)	Matching (ms)	Total(ms)
Daugman(5)	682.5	4.3	686.8
Boles(8)	170.3	11.0	181.3
Wildes(6)	210.0	401.0	611.0
Tan(12)	426.8	13.1	439.9
L.Ma(19)	260.2	8.7	268.9
Proposed	20.6	0.5	21.1

CONCLUSIONS

The thesis have presented an iris recognition system, which have been tested using two data base (namely CASIA and URIRIS) of grayscale eye images in order to verify the claimed performance of iris recognition technology. The results show that segmentation can be the most difficult stage of iris recognition because its success is dependent on the imaging quality of eye images. However with the URIBIS database, only 75% of the images manage to segment successfully due to poor imaging conditions, while 97.34%of the CASIA database images segmented correctly. For the ‘URIRIS v1’ data set, perfect recognition would have been possible with false accept and false reject rates of 0%. A near-perfect recognition rate was achieved with the ‘CASIA v4.1’ data set, it is found from the test results that false accept rate of proposed method is 0.19% and false reject rate of proposed method is 0.26%. These results confirmed that iris recognition is reliable and accurate biometric Technology.

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